Chapter 3
Water Quality and Treatment

Water quality analyst at SPU's laboratory

SPU's water system includes two state-of-the-art water treatment facilities for the Cedar and Tolt source waters. The treatment facilities provide multiple barrier treatment processes to offer high levels of treatment prior to transmission and distribution.

SPU's water system includes two state-of-the-art water treatment facilities for the Cedar and South Fork Tolt source waters, treatment and intake screening facilities at Landsburg, intake screening facilities at the Tolt Regulating Basin, and in-town disinfection facilities at reservoirs and well sites. Each of these facilities is operated and maintained to ensure that the potable water SPU delivers to its customers meets high public health and aesthetic (e.g., appearance, taste, and odor) standards.

This chapter of the *2007 Water System Plan* focuses on the Water Quality and Treatment Business Area, which administers SPU's drinking water quality and treatment programs, projects, services, and capital assets. Key functions of this business area include managing SPU's drinking water regulatory compliance, oversight of the Tolt and Cedar Treatment Facilities and their contract operations, managing distribution system water quality, and overseeing water quality and treatment related capital improvement projects. The Water Quality and Treatment business area is unlike other business areas in that its programs affect infrastructure and practices in the Transmission and Distribution, Water Resources, and Major Watersheds business areas. This chapter also includes descriptions of the drinking water regulatory requirements SPU must meet or exceed, as well as SPU's history of compliance.

3.1 WATER QUALITY AND TREATMENT POLICIES

SPU has developed policies that focus on maintaining drinking water quality from SPU's raw water sources through the treatment, transmission, and distribution systems and all the way to customers' water taps. The following sections describe these policies in greater detail, discuss changes in the policies from the *2001 Water System Plan*, and summarize the key issues and concerns evaluated during development of the policies.

3.1.1 High-Quality Drinking Water Provision Policy

SPU's primary sources, the Cedar and South Fork Tolt Rivers, have exceptional water quality and source water protection, as well as state-of-the-art treatment facilities. Source water protection and treatment together ensure that the quality of Seattle's drinking

water is excellent when delivered to the SPU transmission system. Water from the City's wells also has high quality and natural protection due to the depth of the wells. As water leaves these sources and travels to customer service connections, SPU continues to protect the quality of water through careful attention to the planning, design, operation, and maintenance of the transmission and distribution systems. Covering storage reservoirs helps to protect water quality as the water travels through the transmission and distribution system. After drinking water passes through the customer's meter, there remains an opportunity for water quality to be impaired from customer cross connections and from contaminants, particularly lead, leaching from customer plumbing systems.

SPU revised its water quality policy from the *2001 Water System Plan* to provide new direction on how SPU should approach meeting and/or exceeding drinking water quality objectives. The policy from the *2001 Water System Plan* was updated to reflect the following three major shifts:

- Incorporating the concept of "triple bottom line" (i.e., financial, social, and environmental) cost/benefit analysis.

- Placing an even greater emphasis on managing drinking water quality to protect public health and maintain or improve public confidence, in addition to complying with drinking water quality regulations.

- Recognizing the impracticality of maintaining the same quality of water throughout the system.

Policy Statement

Manage drinking water quality from the water source to the customers tap in coordination with wholesale customers to protect public health, comply with drinking water quality regulations, and maintain and improve public confidence in the drinking water quality.

1. *Factor protection of water quality into the planning, design, operation, and maintenance of all system components, including the transmission and distribution systems.*

2. *Pursue initiatives that further public health or customer confidence objectives when these initiatives are justified by a*

triple-bottom-line analysis, even if regulatory compliance objectives are otherwise being met.

3. *Continue the multiple-barrier approach to protecting water quality that includes source protection and treatment.*

4. *Continue to provide support for maintaining water quality in customer plumbing as deemed appropriate.*

5. *Provide wholesale and retail customers with clear, accurate, and timely information on water quality issues so that public confidence is maintained.*

6. *Support research on emerging drinking water issues and participate in the development of new state and federal legislation and regulations on drinking water quality, both directly and through water utility associations.*

3.1.2 Watershed Protection Policy

By owning most of the land in the Cedar Watershed and 70% of the Tolt Watershed, SPU maximizes source water protection.

For over a hundred years, the City's principal strategy for protecting water quality in its watersheds has been to acquire ownership of watershed lands to control human activities and maximize protection of source water quality. As a result, the City has acquired virtually complete ownership of Cedar River Watershed and approximately 70 percent ownership of the South Fork Tolt watershed (the remaining 30 percent is publicly owned by the US Forest Service). The Watershed Protection Policy provides guidance as to how SPU will manage facilities and activities affecting water quality in the watersheds.

The development of the Watershed Protection Policy followed the emergence of water supply security as an important societal concern. The primary emphasis of this policy is on controlling access to and activities within the watershed. While not previously stated in a single policy, the elements of the policy have been in practice for the past 100 years. Therefore, the policy does not represent a significant shift from past SPU policies and practices as detailed in the *2001 Water System Plan*. This policy will have a small public and social impact as a result of continuation of the restrictions on access to protected watershed areas. The restriction is necessary, however, to protect against greater regulatory, asset, and service reliability, security, financial, and public health impacts.

Policy Statement

Control human activity and be prepared to respond to emergencies in the municipal watersheds to maximize protection of drinking water source water quality.

1. *Require that all individuals and groups have approval from the Director of SPU or designee for access to the municipal watersheds.*[1]

2. *Enforce trespass and other laws and regulations related to municipal watershed access and deterrence of unauthorized use, taking additional security measures when needed along known security trespass corridors or where SPU property is adjacent to residential areas.*

3. *Meet all current federal regulations for unfiltered surface water supply in the Cedar River watershed, including provisions of the Cedar supply's Limited Alternative to Filtration, and filtered surface water supplies in the South Fork Tolt watershed that require the identification of municipal watershed boundaries. Signs, fencing, and gates will be used to meet these regulations and to deter unauthorized use and trespass.*

4. *Prohibit public access for fishing in SPU's municipal watersheds*

5. *Prohibit public access for hunting in SPU's municipal watersheds, unless it is deemed necessary by the Director of SPU for the protection of water quality, allowing tribal hunting in accordance with treaty rights or by specific agreements.*

6. *Pursue land ownership, landowner agreements, and/or legislation to protect SPU municipal watersheds, emphasizing land ownership, when feasible, to provide the greatest level of control and watershed protection.*

[1] See policy regarding watershed recreational trails in SPU's Watershed Recreation Policy.

7. *Aggressively pursue prevention and suppression of all wildfires on municipal watershed lands.*

   a. *Include public education, communication of industrial fire precaution levels, forest patrols, weather monitoring, and fuels management in wild fire prevention program.*

   b. *Prioritize human life and safety (both for the public and for those fighting the wildfires) as highest priority.*

   c. *Then emphasize containment of a wildfire to the smallest acreage possible.*

   d. *Use water from any water body within the Cedar and Tolt watersheds for fire suppression on a case-by-case basis as decided by the Director of SPU or designee.*

   e. *Use fire retardant materials when authorized by the Director of SPU or designee.*

3.2 SERVICE LEVELS

SPU's service level in the water quality and treatment business area focuses on meeting federal and state regulatory requirements. This is captured in a single service level objective and target for drinking water quality as shown in Table 3-1.

Table 3-1. SPU's Service Level for Managing Water Quality and Treatment Assets

Service Level Objective	Service Level Target
Promote a high level of public health protection and customer satisfaction with drinking water quality.	Meet all health-related and aesthetic regulations administered by the Washington State DOH Drinking Water Program for the Seattle regional water system.

SPU's service level target is to meet health-related regulations (i.e., primary maximum contaminant levels and treatment requirements), aesthetic regulations (i.e., secondary maximum contaminant levels), and other aesthetic criteria (e.g., appearance, taste, and odor). SPU has been successful in meeting this service level. In 2005, SPU met all drinking water regulatory requirements. Taste and odor complaints have decreased since SPU began operations at the Cedar Treatment Facility. SPU's approach to continuing to achieve its service level objective is described in the following section.

3.3 EXISTING FACILITIES AND PRACTICES

To achieve its water quality and treatment service level, SPU has expended a great deal of effort over the past decade and continues to make concerted efforts in order to ensure compliance with Washington State Department of Health (WDOH) drinking water regulations. SPU operates facilities, monitors water quality at those facilities, and engages in a number of practices designed to bring safe, high-quality drinking water to its customers. This section summarizes SPU's record of regulatory compliance, identifies SPU's treatment facilities, and summarizes its operation and maintenance practices to ensure excellent water quality and a high level of customer satisfaction.

3.3.1 Regulatory Requirements and Compliance

Federal and state statutes and administrative regulations require the utility to meet certain water quality criteria and performance standards. The following subsections identify the standards and requirements that SPU must achieve and summarize SPU's performance in meeting those standards and requirements.

Total Coliform Rule

SPU collects required monthly samples from its retail service area distribution system and tests for coliforms, which are naturally present in the environment and are used as an indicator of whether other, potentially-harmful, bacteria may be present. As system improvements, especially better disinfection systems, have been implemented over recent years, Seattle's success in meeting the total coliform rule requirements have improved greatly.

SPU has been well within regulatory requirements for coliform since the startup of the Cedar Treatment Facility in 2004.

SPU experienced an increase in positive coliform samples from 2002 to 2004. This was due, in part, to more sensitive laboratory methods for detecting the bacteria. It was also a result of the proliferation of a particular coliform species in Lake Youngs that fed on a large algal bloom in the lake. As indicated by Figure 3-1, SPU has been continuously in compliance with the Total Coliform Rule. Since the startup of the Cedar Treatment Facility in 2004, SPU has been well within the regulatory requirement of less than 5 percent of samples with detectable coliform and no *E. coli*.

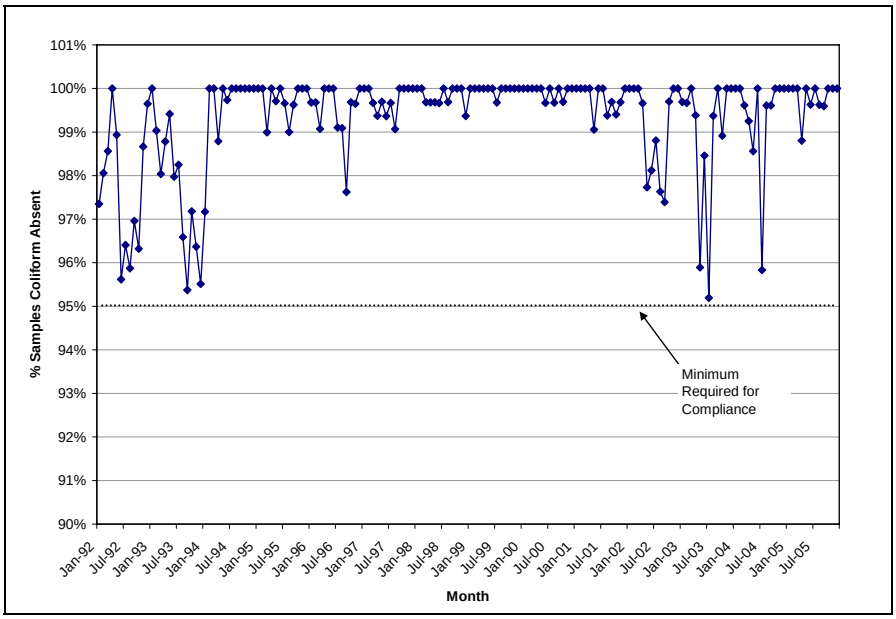

Figure 3-1. Monthly Coliform Data from SPU Water Distribution System

Surface Water Treatment Rule

The Surface Water Treatment Rule (SWTR) contains disinfection and filtration requirements for all public water systems that use surface water or a groundwater source that is under the direct influence of surface water. Several revisions to the original rule have been made since 1989. The latest revision to the SWTR, the Long Term 2 Surface Water Treatment Rule (LT2SWTR), focuses on controlling *Giardia* and *Cryptosporidium* in surface water supplies. Now, both the Cedar and Tolt supplies must be monitored for *Cryptosporidium* for two years. To date, the monitoring results indicate that no additional treatment is required at either the Cedar or Tolt Treatment Facilities to control *Cryptosporidium*.

Tolt Supply. With completion of the Tolt Treatment Facility in 2001, the supply from South Fork Tolt River must meet all the requirements of a surface supply using filtration and disinfection. The Tolt Treatment Facility operations contract includes water quality performance requirements that meet and, in most cases, exceed the regulatory filtration and disinfection requirements. The Tolt Treatment Facility has had no treatment violations since startup.

Cedar Supply. Construction of the Cedar River Treatment Facility was completed in 2004. The Cedar River water supply

system was designated as having "limited alternative to filtration" (LAF) status which authorizes SPU to operate the Cedar source without filtration treatment. LAF status is granted because Cedar source water is produced from a watershed that is 100 percent in public ownership, with no residential, commercial or industrial development, and the treatment system employs a multi-stage disinfection process that provides greater protection against microbial contamination than can be provided by traditional filtration and chlorine disinfection.

Like the Tolt Treatment Facility, the Cedar Treatment Facility operations contract includes water quality performance requirements that meet and, in most cases, exceed regulatory requirements. Since it began operating in 2004, the Cedar Treatment Facility has experienced no treatment violations.

Open Reservoirs. The new requirements of the SWTR require SPU to give WDOH written notice by 2008 as to which approach will be used to meet the new requirements for open reservoirs, and submit a covering plan by 2009. Although SPU already has an open reservoir covering plan approved by WDOH, an update to that plan will be submitted. The covering plan is described in greater detail later in this chapter.

Disinfection By-Product Rule

In general, Seattle's high quality source water and upgraded treatment result in low concentrations of disinfection by-products, such as trihalomethanes and haloacetic acids, two by-products that can result from reactions between chlorine and natural organic matter. Trihalomethane and haloacetic acid monitoring results since 2002 are presented in Figure 3-2 and Figure 3-3. The results are all well below the regulatory limits. Cedar River water has historically been relatively low in disinfection by-products. Disinfection by-product levels in the South Fork Tolt River water decreased substantially with startup of the Tolt Treatment Facility and are now comparable to those of the Cedar source.

To prepare for implementation of the 2006 Stage 2 Disinfectants and Disinfection By-Products Rule that will take effect in 2012, SPU has begun a sampling program to identify sites in the distribution system where the highest disinfection by-product levels are likely to be found, and it has begun compliance testing at those sites. Based on testing conducted to date, SPU does not anticipate much difficulty meeting the by-product limits under the new rule.

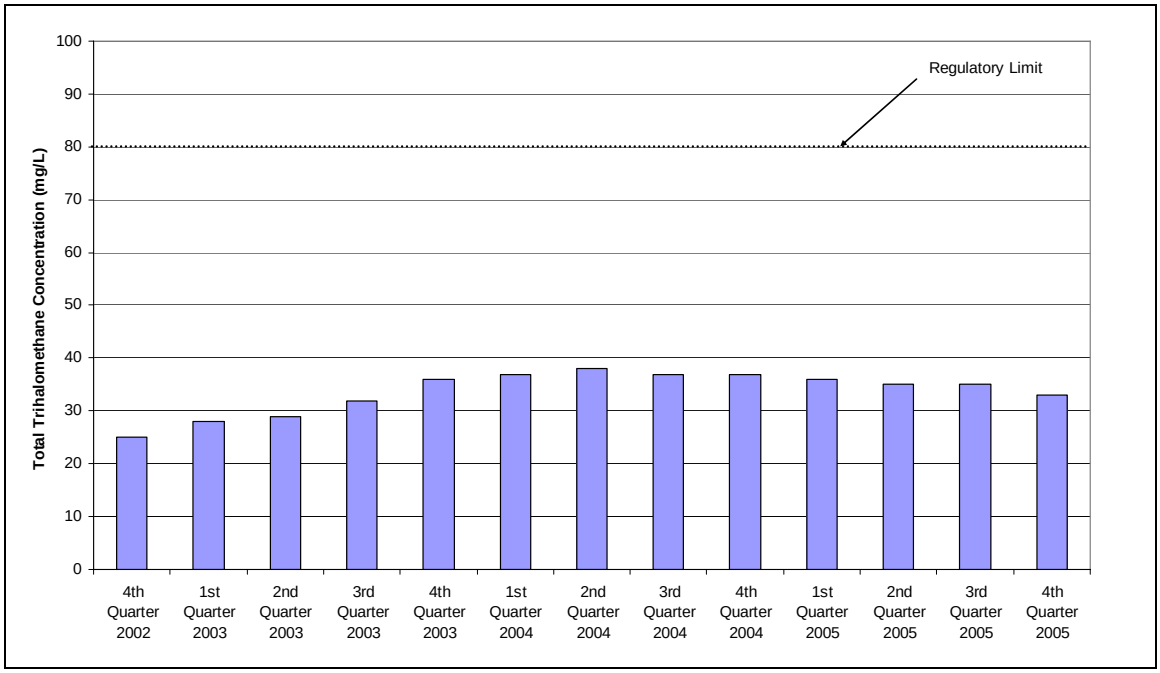

Figure 3-2. Trihalomethane Concentrations, 2002-2005

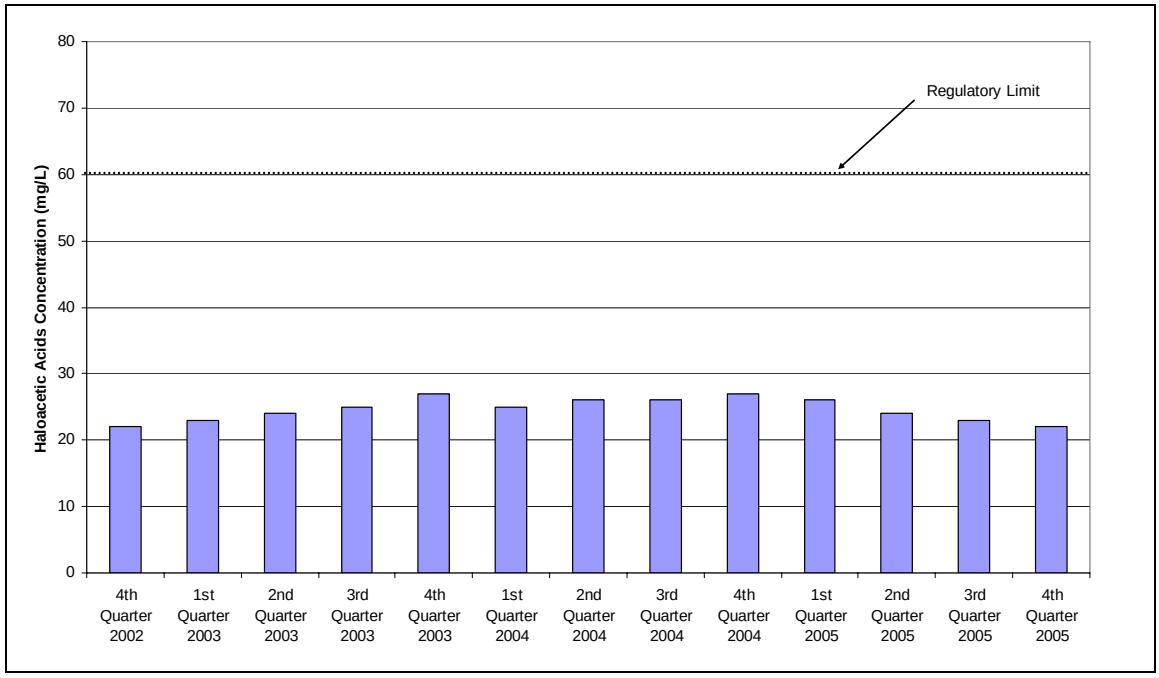

Figure 3-3. Haloacetic Acid Concentrations, 2002-2005

Lead and Copper Rule

Seattle's source and distribution water contains no significant amounts of lead or copper. Household plumbing, however, is

often made of copper, and household systems can include components containing lead, such as lead-tin solder and leaded-brass fixtures, that can leach lead and copper into the water. As a result of exceeding the regulatory action level for lead in 1992 and 1997, SPU negotiated a compliance agreement with WDOH in 1997. SPU has since met the requirements of the compliance agreement through construction of the Tolt Treatment Facility, covering of two reservoirs on the Tolt system, and changes in disinfection treatment at the two reservoirs. Between 2001 and 2004, SPU conducted additional testing to optimize treatment. In 2003 and 2004, two rounds of lead and copper tap monitoring showed that SPU's water system was in compliance with the regulatory limits. In the fall of 2004, the compliance agreement was terminated.

Other Water Quality Monitoring

Source Monitoring. SPU conducts source monitoring for hundreds of potential contaminants, including inorganic chemicals, volatile organic chemicals, synthetic organic chemicals, and radionuclides. None of the Seattle water sources have had chemical concentrations near the compliance limits for any of these contaminants.

Open Storage Monitoring. SPU operates, maintains, and monitors its open reservoirs in accordance with a WDOH-approved open reservoir protection plan, discussed later in this chapter.

Closed Storage Monitoring. Throughout the year, SPU monitors the quality of water within open and covered storage facilities as part of its routine water quality monitoring program. The information guides system operations, reservoir turnover, spot disinfection, or decisions to take facilities out of service for cleaning or other actions.

Taste and Odor Sampling. Taste and odor testing is conducted at least bi-weekly by a trained flavor profile analysis panel at SPU. The testing monitors and characterizes changes in tastes and odors associated with the source waters and distribution reservoirs, especially the open reservoirs. The test data are used to ensure source treatment performance criteria are met and to inform operators about the need to take reservoirs out of service, increase reservoir turnover, overflow reservoirs, or blend sources of supply.

Miscellaneous Monitoring. SPU also conducts water quality monitoring at the Landsburg Diversion on the Cedar River, Chester Morse Lake, Lake Youngs, the Tolt Reservoir, and the Tolt Regulating Basin. Nutrients, algae, and other basic chemical and physical parameters such as pH, temperature, total organic carbon, ultraviolet absorbance, dissolved oxygen, reservoir stratification, and visibility throughout the water column are monitored.

3.3.2 Source Water Protection Programs

SPU's finished water quality is excellent, in part, because of SPU's substantial efforts to protect its water sources. Those source protection efforts are described below.

Watershed Protection

SPU's substantial efforts to protect its water sources helps to ensure that the finished water delivered to customers is of excellent quality.

The primary tool for maintaining source water quality is Seattle's extensive watershed ownership, which allows SPU to restrict human access and activities within the watersheds. SPU has adopted watershed protection programs for the Cedar River and South Fork Tolt River Municipal Watersheds as well as for the Lake Youngs Reservation to ensure that SPU's source water remains of high quality and free from contamination. The programs are described in SPU's *Watershed Protection Plan*, which details SPU's activities to control activities that have the potential to adversely affect water quality in both of its surface water supplies. The Plan was submitted to and approved by DOH in 2004. The only significant change from the *2001 Water System Plan* was the addition of the Lake Youngs Protection Program.

Lake Youngs Protection Program. With the 2004 completion of the Cedar Treatment Facility, Lake Youngs Reservation effectively became a part of the Cedar River hydrographic watershed. SPU's *Watershed Protection Plan* presents a comprehensive discussion of Lake Youngs to reflect this significant change in the configuration of the Cedar supply. It describes the Lake Youngs Reservation physical characteristics; land ownership; and water quality protection measures, such as security and sanitation.

Wellhead Protection

While the two municipal watersheds supply nearly all of Seattle's raw drinking water, Seattle supplements its drinking water supplies with groundwater from the Riverton and Boulevard Park well fields, located in SeaTac, Washington. As part of the *2001 Water System Plan*, SPU prepared and WDOH approved a wellhead

protection program, including inventory of potential contaminants, for both well fields. The program has not changed since 2001, other than the potential contaminant inventory being updated in 2003 and 2005.

3.3.3 Source Water Quality Summary

Water quality characteristics of the raw water from each of SPU's sources, including its three wells, are shown in Table 3-2.

Table 3-2. Water Quality Characteristics of SPU's Source Water, 2000-2005

Surface Water Sources	Cedar River		Lake Youngs		Tolt River	
Parameter and Unit	Average	Typical Range	Average	Typical Range	Average	Typical Range
Turbidity, NTU	0.5	0.2 – 0.8	0.4	0.3 – 0.5	0.9	0.2 – 2.0
Temperature, °C	9	6 - 12	13	7 - 19	9	4 - 15
pH	7.6	7.3 – 7.8	7.6	7.3 – 7.8	6.9	6.6 – 7.3
Alkalinity, mg/L as $CaCO_3$	22	15 - 30	18	14 - 20	5.7	5.3 – 6.5
Conductivity, umhos/cm	56	44 - 71	56	50 - 63	22	20 - 24
UVA (@254 nm), cm-1	0.025	0.01 – 0.043	0.017	0.012 – 0.022	0.061	0.046 – 0.087
Total coliform, per 100 mL	413	48 - 921	960	7 - 2400	83	3 - 200
Fecal coliform, per 100 mL	11	0 - 23	2	0 - 5	1	0 - 2

Groundwater Sources	Boulevard Well		Riverton Wells	
Parameter and Unit	Average	Typical Range	Average	Typical Range
Temperature, °C	12	11 - 13	10	9 - 11
pH	7.0	6.8 – 7.1	7.4	7.2 – 7.8
Alkalinity, mg/L as $CaCO_3$	76	53 - 93	59	24 - 77
Hardness, mg/L as $CaCO_3$	116		83	
Conductivity, umhos/cm	270	238 - 295	195	184 - 219

Contaminants of concern that have been identified in the wells include radon in all of the wells and Dacthal mono- and di-acid degradates in the Riverton Wells. In most years the wells have not been used, but when they were, all customers were notified of the presence of these contaminants in the annual Consumer Confidence Report. These contaminants are currently not regulated by the EPA.

3.3.4 Source Treatment Facilities

As described below, SPU operates treatment facilities at both its surface water sources and at its well field.

Cedar River Treatment Facilities

SPU operates two facilities to treat Cedar River source water, the Landsburg Treatment Facility and the Cedar Treatment Facility. At the Landsburg Treatment Facility, SPU fluoridates and chlorinates the Cedar supply. Prior to the construction of the Cedar Treatment Facility at Lake Youngs, the Landsburg Treatment Facility was the primary disinfection site for water from the Cedar River watershed. Since the addition of ultraviolet (UV) disinfection and ozonation at Lake Youngs, the chlorine addition at Landsburg serves to control invasive plant species (e.g., algae from Chester Morse Lake) in Lake Youngs and minimize microbial growth in the transmission pipeline between Landsburg and Lake Youngs.

The new Cedar Treatment Facility uses ozone, UV, and chlorine applied in series to ensure inactivation of Giardia, Cryptosporidium, and viruses.

The new Cedar Treatment Facility uses ozone, UV, and chlorine applied in series to ensure inactivation of *Giardia*, *Cryptosporidium*, and viruses. These processes also improve the taste and odor of the water from this source. The new facility has a capacity of 180 mgd.

The Cedar Treatment Facility is operated under contract by Operations Management International (OMI). The 15-year contract with OMI began in late 2004. SPU has the option to renew the contract for up to two additional, 5-year periods. At the 15- and 20-year marks, SPU will have the option to renew the existing contract, hire another operations contractor, or use SPU staff to operate the treatment facility.

South Fork Tolt River Treatment Facility

The Tolt Treatment Facility produces water comparable in quality to that of the Cedar.

A 120-mgd ozonation and direct filtration treatment facility for the South Fork Tolt River water began operation in 2001. The facility also provides fluoridation and chlorination and adjustment of pH and alkalinity for corrosion control. Treatment provided by the Tolt Treatment Facility has resulted in finished water quality comparable to that produced by the Cedar Treatment Facility.

The Tolt Treatment Facility is operated by American Water Services Camp Dresser & McKee. The 15-year operations contract began in 2001 and will expire in 2015. SPU has the same

contract renewal options at the 15- and 20-year marks as it has for the Cedar Treatment Facility.

Well Field Treatment Facilities

Both well locations include sodium hypochlorite disinfection to provide chlorine residual in the distribution system, fluoridation, and sodium hydroxide addition for corrosion control. Although sodium hydroxide addition is not required, it makes the well water quality more consistent with that of treated water from the Cedar River, with which it is blended before it is delivered to SPU customers.

Condition of Source Treatment Facilities

Because of their recent construction, the Cedar River and Tolt treatment facilities are both in excellent condition. The treatment equipment at the well fields is also relatively new, and in very good condition. The Landsburg Treatment Facility is older, and SPU is in the process of analyzing alternatives to upgrade the mechanical equipment and structural components of the chlorination facilities.

Overall Finished Water Quality

The water quality characteristics of treated water as it enters SPU's transmission system are shown in Table 3-3.

3.3.5 In-Town Storage Facilities

In addition to its facilities in the watersheds and at Lake Youngs, Seattle operates several water storage facilities within its service area, including open reservoirs, covered reservoirs, and standpipes and elevated tanks. SPU operates these facilities to ensure that water quality within the distribution system is protected. SPU has established a regular program of inspections for the open and closed reservoirs and reports the results of the surveys to WDOH.

Table 3-3. SPU's Finished Water Quality Characteristics

Surface Water Sources	Cedar/Lake Youngs (2005)		Tolt River (2001-2005)	
Parameter and Unit	Average	Typical Range	Average	Typical Range
Turbidity, NTU	0.5	0.2 – 0.8	0.05	0.02 – 0.1
Temperature, °C	13	4 – 25	10	4 – 15
pH	8.2*	8.0 – 8.4	8.2*	8.0 – 8.4
Alkalinity, mg/L as $CaCO_3$			19	18 – 20
Conductivity, umhos/cm	74		51	
UVA (@254 nm), cm-1	0.011	0.007 – 0.013	0.013	0.011 – 0.015
Chlorine residual, mg/L	1.4*	1.3 – 1.5	1.5*	1.4 – 1.6

Groundwater Sources	Boulevard Park Well (2000-2005)		Riverton Wells (2000-2005)	
Parameter and Unit	Average	Typical Range	Average	Typical Range
Temperature, °C	13	12 - 14	11	9 - 12
pH	8.25*		8.25*	
Alkalinity, mg/L as $CaCO_3$	104		88	
Conductivity, umhos/cm	327	285 - 362	259	206 - 348
Chlorine residual, mg/L	1.0*		1.0*	

* Treatment target or criterion

Reservoir Covering/Burying

The approach for covering the open reservoirs has changed significantly since the *2001 Water System Plan*. In early 2001, SPU intended to cover most of the open reservoirs with relatively inexpensive, floating covers to retain most of the existing storage volume. Primarily because of heightened concerns about security following September 11, 2001, but also to create more open space in Seattle, SPU now plans to replace most of the open storage with new underground reservoirs and to accelerate the construction schedule. The replacement projects represent a significant amount of work. Table 3-4 summarizes the revised plan.

Table 3-4. Schedule for Covering or Upgrading In-Town Open Reservoirs

Reservoir	Open Reservoir Size (million gallons)	Covered Reservoir Size (million gallons)	Completion
Bitter Lake	22	22	2003(1)
Lake Forest Park	60	60	2003(1)
Lincoln	20	12	2006
Myrtle	7	5	2007(3)
Beacon	61	50	2008(3)
Roosevelt	50	0	2015(3)
West Seattle	68	30	2010(3)
Maple Leaf	60	60	2013(3)
Volunteer	20	0 or 10(2)	2015(3)
Total	369	239	

Notes:

(1) Floating cover, but likely to be replaced with buried storage at end of useful life of floating cover (about 20 years).

(2) Although modeling shows that the benchmark emergency scenarios can be met without storage at Volunteer, a decision to decommission the reservoir site has not been finalized. The decision requires further operational experience to determine the importance of the reservoir to normal system operations. If a new, covered reservoir is constructed, the likely size would be 10 million gallons.

(3) Estimated date of substantial completion.

The table shows that the Roosevelt Reservoir will be decommissioned and that some of the new reservoirs will be significantly smaller than the open reservoirs they replace. The Volunteer Reservoir may also be decommissioned rather than replaced. Using the methodology described in the *2001 Water System Plan*, SPU performed additional modeling of emergency scenarios to verify that the reduced storage is adequate for future needs. Also, the system will be operated with the Volunteer Reservoir taken off line for a length of time to verify that it is not needed for normal system operations. If that proves to be the case, the Volunteer Reservoir will be decommissioned.

Open Reservoir Protection Plan

In order to ensure that the quality of treated water is not diminished during its residence in open reservoirs, SPU operates and maintains its open reservoirs in accordance with a WDOH-approved, open reservoir protection plan. This plan includes provisions for reservoir maintenance and operation, security, water quality

monitoring at locations within the reservoir itself and just downstream of the chlorine addition, follow-up actions, and emergency response.

Water Quality Enhancements at Storage Facilities

Some of SPU's enclosed storage facilities were constructed with a common inlet and outlet, or were otherwise designed without considering the optimal water flow conditions needed to maintain water quality by avoiding stagnant conditions. SPU has been modifying its enclosed storage facilities to improve water-quality management. Upgrade methods include separation of inlets and outlets, installation of mixing systems, multiple level sample taps, and sodium hypochlorite injection points.

In-Town Reservoir Treatment

Additional chlorination is provided at some of SPU's in-town storage reservoirs to ensure that chlorine residual is maintained in the drinking water supply until it reaches customer taps. In most cases, the treatment involves addition of sodium hypochlorite to increase the residual chlorine. At some reservoirs, hypochlorite is generated on-site, while at other reservoirs it is delivered to the reservoir site. Open reservoirs that were using chlorine gas are being converted to sodium hypochlorite. All of the hypochlorite and chlorine gas equipment is in good condition. A list of the chlorination facilities is provided in the treatment facilities inventory in the appendices.

3.3.6 Distribution System Facilities

During the last few years, SPU has made an unprecedented number of changes to distribution system facilities to ensure that its retail customers receive high quality drinking water. SPU's water quality-related improvements in distribution system include:

- Requirement that manufacturers of ductile iron pipe adopt special quality control procedures to eliminate on-going taste problems that the linings of some new pipes were causing in the Seattle distribution system.

- Installation of innovative mixing systems in new reservoirs and standpipes to help ensure that disinfectant residuals are well distributed throughout storage structures, thereby preventing microbial growth.

- Development of an EPANET hydraulic simulation model of the system, which can also model water quality in the distribution system in support of operational and design decisions

- Conversion of booster chlorination systems from pH-reducing chlorine gas to hypochlorite systems with a higher pH to reduce corrosion potential as well as safety and security concerns.

3.3.7 Operations

SPU operations ensure that its customers receive high quality drinking water.

SPU undertakes a number of activities to ensure that its customers receive high-quality drinking water. Operations activities include water quality monitoring, preventing or eliminating cross connections, water main testing and flushing, and storage reservoir cleaning. Each activity is summarized below.

Comprehensive Water Quality Monitoring Plan

An updated comprehensive monitoring plan was developed in 2006 and is included as an appendix. The Comprehensive Water Quality Monitoring Plan covers the entire water system, from the watersheds through the transmission and distribution systems to the customer taps. The monitoring plan addresses the following:

- Monitoring requirements under state and federal drinking water regulations.

- Future regulations, which are currently under development at the federal level.

- Non-regulatory monitoring, which SPU conducts for informational purposes and to assist in operating the water system.

- Sampling procedures.

- Managing laboratory information.

- All parameters, locations, and frequency of monitoring conducted by SPU.

Cross-Connection Control Program

SPU's cross-connection program is a joint undertaking with Public Health Seattle-King County (PHSKC). The program includes elements to isolate and disconnect cross-connections both on the

customer's premises and off. The updated cross-connection control policy and procedures are included as an appendix.

New Water Main Testing

New mains are disinfected and tested per American Water Works Association standards as detailed in Section 7-11.3(12) of the City's *Standard Specifications for Municipal Construction*.

Distribution Storage Facility Mixing and Cleaning

A key to maintaining water quality after the treated water enters the distribution system is making sure that storage facilities are kept clean and free from contamination. SPU has reduced total coliform levels throughout its distribution system by increasing reservoir cleaning and turnover.

Storage Facility Cleaning. SPU ensures its in-town, open reservoirs are drained and cleaned at least annually to protect water quality. Cleaning employs high pressure cleaning equipment to remove algae and debris buildup; then the facilities are disinfected before they are put back into service. Table 3-5 summarizes the cleaning frequency and timing for SPU's open reservoirs.

Table 3-5. Annual Open Reservoir Cleaning Schedule

Open Reservoir	Spring	Fall
Roosevelt		X
Maple Leaf	X	
Volunteer	X	X
West Seattle	X	

SPU monitors water quality analytical results and customer complaints to identify trends that indicate that more frequent cleaning is necessary.

SPU also ensures that its enclosed storage facilities are regularly cleaned to ensure water quality protection. SPU's approximate cleaning frequency for closed storage facilities is shown in Table 3-6. These cleaning frequencies may be adjusted based on inspections. Facilities that store Cedar water are on a more frequent cleaning schedule than those that receive Tolt water because the Cedar supply is not filtered.

Table 3-6. Closed Storage Cleaning Schedule

Type of Reservoir	Frequency of Cleaning
Elevated tanks or standpipes	3 years - Cedar supply 25 years - Tolt supply*
Hard-covered reservoirs	3 years - Cedar supply 25 years - Tolt supply*
Floating covered reservoirs	25 years – Tolt supply*
Floating covers (top of cover only)	Annually

*Assumes a 5-year inspection frequency

Water Main Flushing

The primary objective of SPU's water main flushing program is to improve water quality in the water distribution system and to reduce customer complaints regarding discolored water and unacceptable taste and odor. SPU has a program to perform both reactive and preventive water main flushing.

In 2005, under a pilot program, SPU began testing unidirectional flushing to bring water through the system in a controlled fashion at velocities sufficient to scour the distribution piping. The technique consists of isolating a particular section or loop, typically through closing appropriate valves, and exercising the hydrants in a sequential manner, progressing from the water source to the periphery of the system, from large-diameter to smaller-diameter pipes, and always from cleaned sections to dirty ones. System- or zone-wide unidirectional flushing is proactive, and its benefits can be long-term in nature. SPU will be evaluating the results of its unidirectional flushing pilot program in the near future to understand better the costs vs. benefits and to make an informed decision as to whether or not the unidirectional approach should have a long term place in SPU's distribution system management.

3.3.8 Strategic Asset Management Plans for Water Treatment Infrastructure

SPU is developing a strategic asset management plan (SAMP) for drinking water facilities, including in-town disinfection facilities. This SAMP will describe the infrastructure, their operations and maintenance, relevant service levels, repair and replacement needs, data needs, and other relevant asset information.

3.4 NEEDS, GAPS, AND ISSUES

SPU works diligently to maintain its excellent water quality and consistently meet federal and state regulations. In the past decade, SPU has made significant strides towards ensuring that its water is of the highest quality while meeting current and future regulations. In particular, SPU's recent completion of the Tolt and Cedar Treatment Facilities has significantly improved SPU's water quality. In addition, SPU's recent and planned activities to cover, bury, or decommission its open reservoirs also demonstrate SPU's efforts towards ensuring excellent water quality in its system.

There are always new challenges for SPU to confront as it strives to meet its high standards for drinking water quality. The following sections summarize the needs, gaps, and issues facing the Water Quality and Treatment business area and describe SPU's plans to address them.

3.4.1 Future Regulatory Changes

SPU will continue to stay informed on new water quality regulations and will develop plans to address issues that arise.

The federal government is expected to pass a number of new water quality regulations over the next several years. These include the radon rule, which was originally proposed in 1999, the groundwater rule for which the U.S. Environmental Protection Agency (EPA) is expected to issue a final rule in August 2006, and revisions to the total coliform rule and lead and copper rule. These future regulations and their expected impacts on SPU are summarized in Table 3-7.

As noted in Table 3-7, the proposed radon rule, groundwater rule, and revisions to the total coliform rule and lead and copper rule could have minimal to moderate impacts on SPU's infrastructure and practices. Since the final form of the proposed rules and revisions and their impacts are still unclear, SPU plans to stay informed on the status of the rules. As the rules become clearer, SPU will develop comprehensive action plans to address any potential issues that arise.

Table 3-7. Future Regulations and Impact on SPU

Regulation or Issue	Provisions	Impact or Consideration
Radon Rule	Proposed both an MCL of 300 pCi/L and Alternative MCL of 4,000 pCi/L.	Seattle wells would require treatment or blending prior to supplying customers to comply with MCL, but they are currently below Alternative MCL. Blending would likely be the more economical alternative, but a final decision would need to be supported by a more detailed analysis. No radon detected in Tolt or Cedar.
Groundwater Rule	Proposed hydrogeologic assessment and possible source water quality monitoring and new treatment criteria.	Protected nature of aquifer for Seattle wells means that it is unlikely that new treatment requirements would be imposed.
Total Coliform Rule Revisions/ Distribution System Rule	Range of issues may be added or changed from indicator organisms and monitoring strategies to distribution system operation and maintenance.	Many issues are on the table for addition or revision in the rulemaking. All issues are of interest, but none are of severe major concern for SPU at this time.
Lead and Copper Rule Revisions	Near-term revisions likely to refine how compliance is demonstrated. Long-term issues could be more significant, including lead action level and lead in plumbing components.	Near-term revisions unlikely to have significant impact on SPU. Some adjustment may be needed to monitoring plan and schedule. Impact of long-term revisions could potentially be more significant, but changes not clear at this time.

3.4.2 Emerging Contaminants of Concern

New and emerging contaminants are continually being identified and researched by the scientific community. Currently, the EPA is evaluating contaminants on the second Candidate Contaminant List (CCL2) to determine whether these contaminants represent a health risk and, if by regulating a specific contaminant, a health risk would be minimized. Regulatory determinations are expected to be made on some of the contaminants by 2008. The CCL2 includes 42 chemical contaminants and 9 microbial contaminants.

The majority of the CCL2 contaminants present relatively low concern to SPU because of its excellent source protection practices, state-of-the-art treatment facilities, and distribution system practices. One exception is the di-acid degradates found at very low levels in the Riverton Wells. Also, there are three

microorganisms and one chemical on the list that are potential concerns because of their common presence in the environment. The three microorganisms are *Mycobacterium Avium Complex (MAC), Aeromonas hydrophila,* and *Cyanobacteria*; and the chemical is aluminum. Although current treatment at the sources should provide an effective barrier to the microorganisms, the open reservoirs will provide an alternate route of entry until they are covered.

The majority of the CCL2 contaminants present relatively low concern to SPU.

Without knowing which of these contaminants EPA will decide to regulate, or where it might set maximum contaminant levels, it is not known at this time what changes, if any, could be required of SPU in the future. SPU plans to continue monitoring the presence of these contaminants in the distribution system and participate and/or stay informed on national studies on occurrence, treatment, and health impacts. SPU also plans to stay abreast of EPA's regulatory determination on di-acid degradates planned for 2008. Finally, SPU is keeping informed on changes to EPA's process for developing the Candidate Contaminant List (CCL). Recent recommendations were proposed by the National Drinking Water Advisory Council on how to revise the CCL development process. These changes may be formally adopted by the EPA over the next several years.

Two additional emerging contaminants, MTBE and perchlorate, have received increasing national attention in recent years, but are not concerns for SPU. MTBE is a gasoline fuel additive that has been used since the late 1970s. Perchlorate is a strong oxidizer that is present in paints, oils, aircraft oxygen generators, flares, and other sources. There is a high likelihood that the EPA will propose to regulate perchlorate and MTBE in 2008. However, the impact of regulation on SPU will be low, since SPU's sources have no history of detectable levels of those contaminants, and there is little possibility of future contamination.

Also receiving increased attention, and not a concern for SPU, are endocrine disrupter chemicals (EDCs) and pharmaceuticals and personal care products (PPCPs). EDCs and PPCPs include drugs, hormones, preservatives in cosmetics, and other personal care product chemicals that have been detected in water supplies located downstream of wastewater discharges. None of SPU's water sources are downstream of any wastewater discharges, so these contaminants are not of concern to SPU water quality.

3.4.3 Water Quality at the Tap

While SPU delivers high quality drinking water to its customers' meters, concerns have grown about on-property water quality as a result of cross-connections and lead leaching in building plumbing. These concerns arose as an issue in schools and have generated discussion about how SPU can best ensure that the public health and customer confidence objectives of its drinking water quality policy are adequately addressed.

SPU is evaluating additional initiatives to improve water quality at the tap.

SPU and PHSKC are jointly implementing a cross-connection control program as described earlier. SPU minimizes leaching of lead and copper from in-house plumbing through a corrosion control program, which includes pH and alkalinity adjustment. In its efforts to enhance public health and consumer confidence, SPU is evaluating additional initiatives to improve water quality at the tap. Some possible future programs that may be evaluated include:

- Modifying cross-connection control program to address emerging concerns like intrusion of residential gray water, reclaimed water, and water from rain barrels into the distribution system.
- Providing support to resolve lead concerns at schools and daycare centers.
- Supporting point-of-use treatment. This support could range from helping customers select treatment equipment to SPU maintaining treatment equipment under contract.
- Providing laboratory support in the form of services that could range from providing customers with a list of certified labs to offering free lab analysis of customer samples.

SPU plans to evaluate these initiatives and others using asset management techniques, including triple-bottom-line analysis, as well as customer willingness to pay surveys. Potential legal risks associated with taking actions that directly or indirectly affect private property will be given careful consideration as part of the evaluation.

3.4.4 Kerriston Road in the Cedar River Watershed

Kerriston Road is a King County road, about two miles of which are within the hydrographic boundary of the Cedar River watershed in the vicinity of Brew Hill. The road represents about 8 of the 230 acres of land in the watershed not owned by the City.

WDOH has expressed concern about the potential public health and water quality impacts that could result from public use of the road. SPU proposes to conduct a comprehensive analysis of the risks presented by public access on the Kerriston Road to the Cedar River watershed. The analysis will include feasibility studies and cost estimates for all of the risk management options that are developed.

3.4.5 Lake Youngs Water Quality

Water quality in Lake Youngs has been changing in recent years, as evidenced by an increase in algal blooms and decreasing levels of oxygen at certain depths within the lake. As a result of the changes, there are concerns of deteriorating water quality in the lake, and in particular, increases in the amount of phosphorus and iron in the lake. As of yet, SPU is seeing only slightly increased concentrations of phosphorus in the Lake Youngs outlet, while iron levels show a definite upward trend. Phosphorus can result in more algal blooms. Additional data indicators such as clarity in the lake, total organic carbon, zooplankton counts, UV absorbance, and temperature have all shown changes. The exact cause of the water quality changes is still unclear.

SPU plans to address the changes in Lake Youngs water quality by further characterizing the lake and its constituents. In particular, SPU is currently in the process of implementing a monitoring plan which includes testing for dissolved organic carbon. Iron and manganese analysis will also be added to try to capture any patterns or trends in the water quality of Lake Youngs. Characterization of the lake will enable SPU to best address the water quality concerns through a well-informed mitigation plan, as necessary.

3.4.6 Well Field Readiness

The Riverton and Boulevard Well Fields provide important backup emergency supply and are available to supplement surface water supplies during moderate to severe drought conditions. Over the last fifteen years, the wells have been used infrequently. In the event of an outage of the Cedar source, the wellfield would be critically important to the continuance of supply because the wells are located in the part of the system that is most difficult to serve from the Tolt source.

While it is important for SPU to have backup water sources, several water quality-related factors complicate the start-up and

operation of the wells, detracting from their value as emergency supplies. These complicating factors include

- **Treatment.** Some of the treatment chemicals deteriorate over time and cannot be kept at the wells. Delivery of chemicals to the site can take three days, delaying start-up in emergencies. It is recognized, however, that in some emergency situations, untreated well water could be delivered to customers while the treatment processes and chemicals are being readied without short term regulatory consequences.

- **Blending.** Although the mineral content of the well water is relatively low for groundwater, it is significantly higher than for Cedar River water, which could present a problem for some commercial customers. To compensate, well water is blended with Cedar River water before it is delivered. If the Cedar River source were out of service, an emergency situation where the wells would play a crucial role, achieving the blending objectives becomes impossible.

- **Flushing.** When the wells have been inactive for an extended period, the first water pumped will be high in rust and sediment, and the well water must be diverted to the stormwater system for a few hours until the rust and sediment has been flushed out. Because of increased restrictions on the timing and rate of discharge to the area's drainage system, the disposal of flushing water has become more problematic.

- **Maintenance.** Routine maintenance at the wells is budgeted and performed to keep them in a state of readiness such that they can be activated within 14 days. This includes all of the mechanical, electrical, control, and treatment equipment. To have the wells in a higher state of readiness and available more quickly would require additional maintenance efforts and cost.

Because SPU considers the wells an essential component of supply to meet customer demand in the event of a Cedar outage, the Tolt/Cedar transfer improvements study, which is discussed in Chapter 4, will address the issue of well readiness as it relates to the time required to respond to a supply emergency. This study may lead to a detailed evaluation of the costs and benefits of continuing operation of the wells and formulation of a long-term strategy for the operation and maintenance of the wells.

3.5 IMPLEMENTATION/ACTION PLAN

With its construction of new treatment facilities, reservoir covering, and water quality management activities, SPU has accomplished a great deal since 2001. These actions have resulted in SPU meeting drinking water quality regulations and have placed SPU in position to continue to meet water quality requirements in the future. In addition, SPU has an ambitious list of important projects and actions in the Water Quality and Treatment business area that include the following:

- Continue implementing the open reservoir covering and replacement program; explore decommissioning of Volunteer Reservoir; provide written notice to WDOH by 2008 on the approach that will be used to meet the new requirements of the surface water treatment rule; submit and obtain WDOH approval on an updated reservoir covering plan by 2009.

- Stay abreast of EPA and WDOH regulatory development efforts and make adjustments as necessary to ensure that SPU's water quality service level is always met.

- Continue monitoring the science regarding new or emerging contaminants of concern, and continue to monitor source and finished drinking water to determine whether these contaminants are at levels of concern in SPU's supplies.

- Continue to evaluate approaches to helping SPU customers maintain excellent water quality in their own plumbing systems.

- Investigate management options for Kerriston Road to ensure that it does not threaten Cedar source water quality.

- Continue to monitor and characterize limnological conditions in Lake Youngs as it affects Cedar supply operations and raw water quality.

- Address the issue of readiness of Seattle Well Fields as it relates to the time required to respond to a supply emergency.

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